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ANNULAR CURVES OF THE OSMOTIC PRESSURE OF CERTAIN PLANTS ON THE CAPE FLATS

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In continuation of the investigation of Walter and van Staden (1) the osmotic pressure of the cell—sap of the following species, growing on the campus of the U.C.W.C., was determined, at convenient intervals, for a period of one year: *Othonna coronopifolia* L., *Leucospermum hypophyllum* R. Br., *Euclea racemosa* Murr., *Rhus mucronata* Thunb. and *Olea africana* Mill. As shown by Braun—Blanquet and Walter (2) the annular curve of the osmotic pressure of some typical representatives of the flora would be representative of the water conditions of the flora in general.

The campus is situated on the Cape Flats near Bellville. It is a flat, sandy stretch of land with sand dunes on the western side of the campus which have an East-West exposition. The dunes vary in height up to four metres above the immediate environment. The altitude is approximately the same as that of the Bellville railway station which is given as 70 m (230 ft.).

There are few indications as to the depth of the water-table. During the rainy season small waterpools are not uncommon, and trenches dug for constructional purposes are often flooded. This has led to the belief that the water-table is very shallow. Walter and van Staden (1) mention a depth of 5 m during the rainy season and 8 m during the dry season. A borehole drilled on the campus to a depth of 50 m yielded only a couple of hundred L/h. Thus it appears that the water-table is deeper than generally believed.

O. coronopifolia, a shrub usually less than 1 m high with semi succulent leaves, and *L. hypophyllum*, a trailing shrub with partially subterranean stems, grow on the flat sandy surface while *E. racemosa*, *R. mucronata* and *O. africana* grow approximately 150 m to the west on the sand dunes. Material of the latter three species was collected at the foot of a dune while leaves of *O. africana* were also collected on top of the dune.

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Materials and Method:

At convenient intervals leaf samples, less than six months old, were double collected close to the growing tip; and, similarly, leaves of the previous growing season, the latter naturally being more than six months old. Material was always collected on clear sunny days at about 11 o'clock. The leaves were directly placed in glass vials with the tops well screwed down to prevent the loss of water by evaporation.

In the laboratory the closed vials were placed in a glass beaker with water and boiled for five minutes to kill the leaves. According to Walter (3) this method yields the most reliable results as it also stops enzymic action which influences the osmotic pressure of the cell-sap. The vials which were available for the present investigation were, to a certain extent, unsuited for the purpose as a complete sealing off could not always be effected. Vials giving off bubbles were immediately removed and the material was not used for the purpose of this investigation. The method was soon discarded and chloroform fumes were used to kill the plant material. The vials were then kept in a refrigerator overnight to prevent further enzymic action. As Walter (4) points out, these fumes are soluble in water and influence the depression of the freezing point of water by —0.102°C. (4). The results were accordingly corrected.

The material was then placed in a pressure cylinder of stainless steel, with a perforated base and a tight-fitting piston. Pressure was slowly applied and steadily increased by means of a hand press, and the cell-sap collected in a vial in a closed space where evaporation was practically nil.

The depression of the freezing point was determined in a microcryoscope, by means of a Beckman thermometer and the osmotic pressure determined from the tables published by Walter (4).

Double collecting ensured a check on the results. On the whole there was a large measure of correspondence, but in a few cases there was an appreciable difference. However, the graph was in all cases drawn to a point between the two values if these did not coincide.

Climatic data were obtained from the weather station at the D. F. Malan Airport situated on the Cape Flats about two miles from the campus. The difference in climate is hardly appreciable.

The climatic graph published by Walter and van Staden (1) is typical for winter rainfall areas, except that the summer months are not completely rainless. With the exception of the few light showers registered during each month, there were often mornings with a light drizzle that cannot be measured by conventional means. Although summer showers are generally light, they may often be quite considerable as during November, when more than 250 mm were registered for one day. March was the driest month with a reasonably high temperature. During the winter months there was a fairly even distribution of the rainfall.

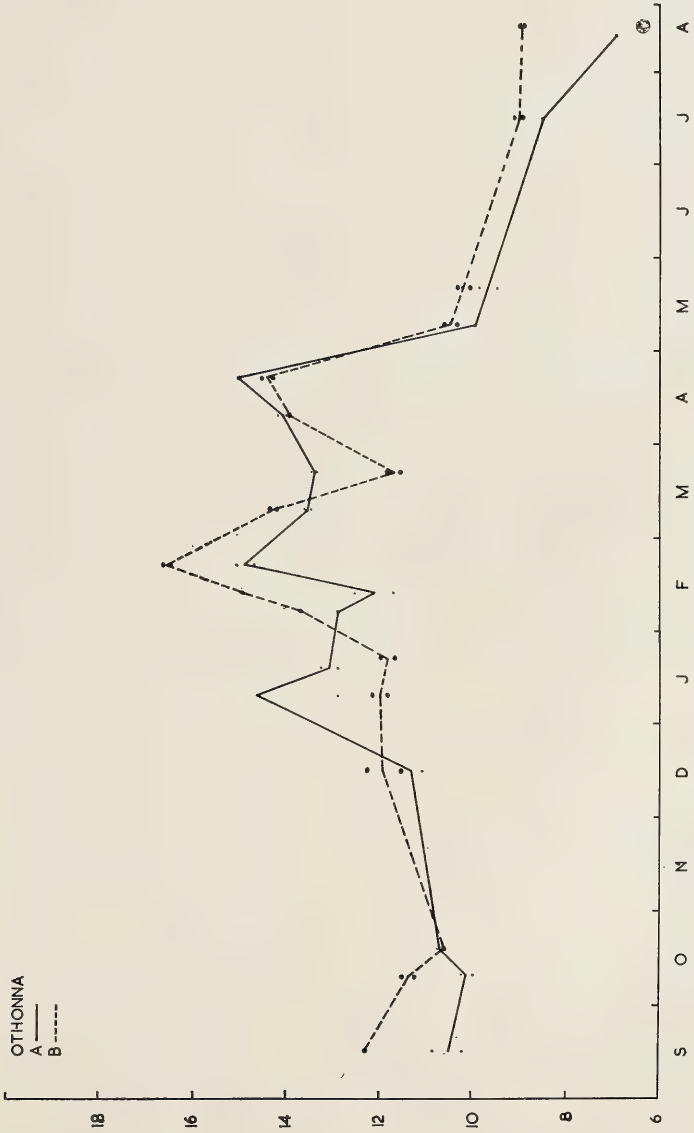

FIG. 1. Osmotic Pressures of *Othonna coronopifolia* L.

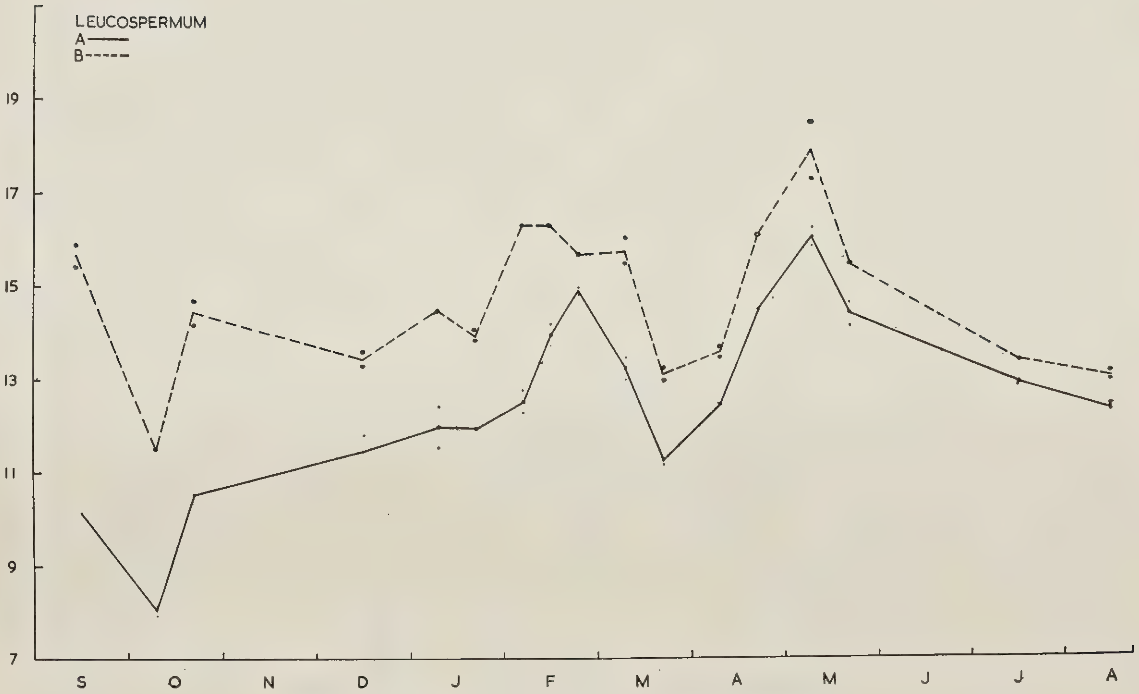

FIG. 2. Osmotic Pressures of *Leucospermum hypophyllum* R.Br.

Throughout the summer the temperature seldom rose above 30°C, the highest maximum being recorded on the 27th December, 1967, namely 35°C. Similarly, the temperature seldom dropped to zero. The lowest minimum was recorded on the 17th August, 1968, namely —0.2°C — a very mild climate therefore, with very little frost and few really hot days. During the summer months, however, the South-Easter which is a dry wind, blows almost daily. Transpiration can thus become excessive.

The graphs show the osmotic pressure along the ordinates and the months from September, 1967 to August, 1968 along the abscissae. The values for the double collections are indicated and the graph is drawn to the middle point between these two, even where one value is apparently wrong. The solid line A indicates the values obtained for the cell-sap of the young leaves and the broken line B for that of the older leaves. In the composite graph Fig. 7 only the values obtained for the cell-sap of the young leaves have been indicated. The rainfall graph shows the precipitation in mm. as measured at the D. F. Malan Airport.

Othonna coronopifolia (Fig. 1): The two determinations for the osmotic pressure of each point largely coincide closely, the difference being less than one atmosphere, thus within the limits of the experimental error. The exception is the first determination for A during January. The difference of over three atmospheres indicates a very appreciable error. Its nature, however, is unknown. On the whole the graph indicates a low osmotic pressure during the rainy season and a rise during the dry summer months. The difference of approximately seven atmospheres between lowest and highest osmotic pressure is relatively small and indicates a hydro-stable condition. This is in accord with the general results concerning succulents (5).

Although the osmotic pressure of the older leaves is generally higher than that of the younger, the graph of the former did sometimes sink below that of the latter.

It should be pointed out that, with the advancing summer, the older leaves were gradually cast off until none remained. Thus, at the end of summer there was little age difference between the oldest and youngest leaves. The abnormal decline of the osmotic pressure of the older leaves during the latter part of the summer is thus understandable.

Leucospermum hypophyllum (Fig. 2): These plants grow approximately 50 m away from the former under more or less similar edaphic and climatic conditions. Again the graphs followed the climatic conditions within reasonable limits and rose from 8·5 atmospheres in September, 1967 to 17·9 atmospheres in May, 1968. In spite of a more xerophytic type of leaf these values do not differ much from those of the semi leaf succulent *O. coronopifolia*. The reaction to climatic

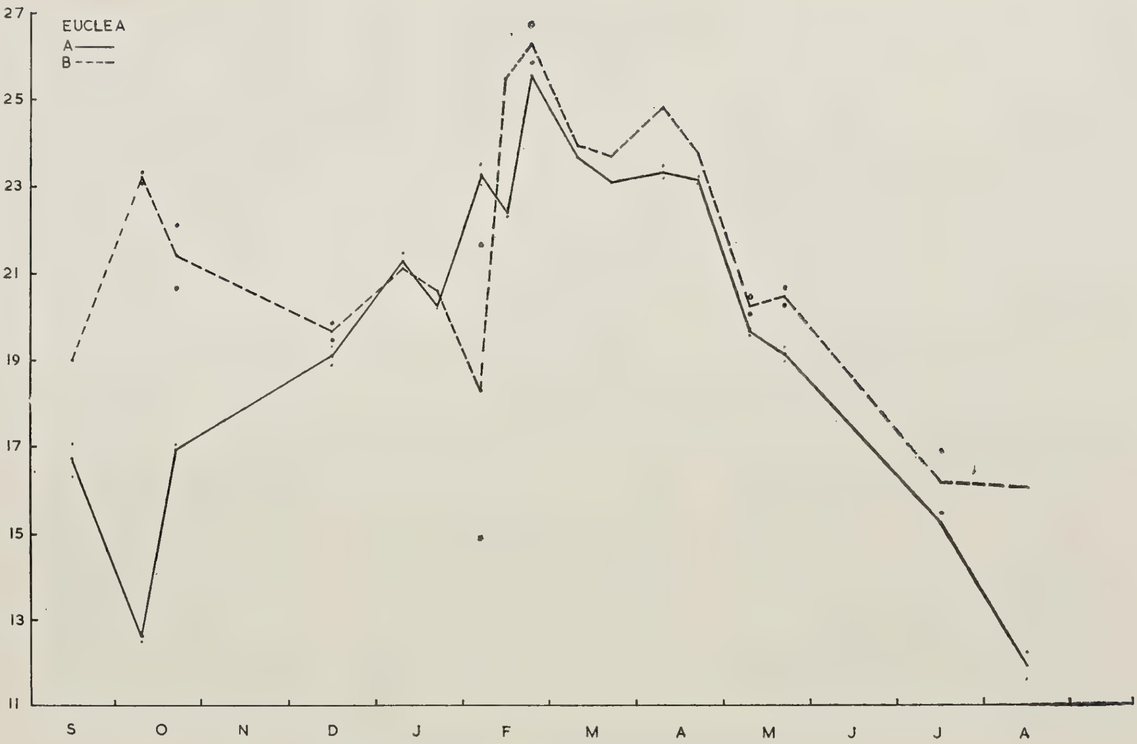

FIG. 3. Osmotic Pressures of *Euclea racemosa* Murr.

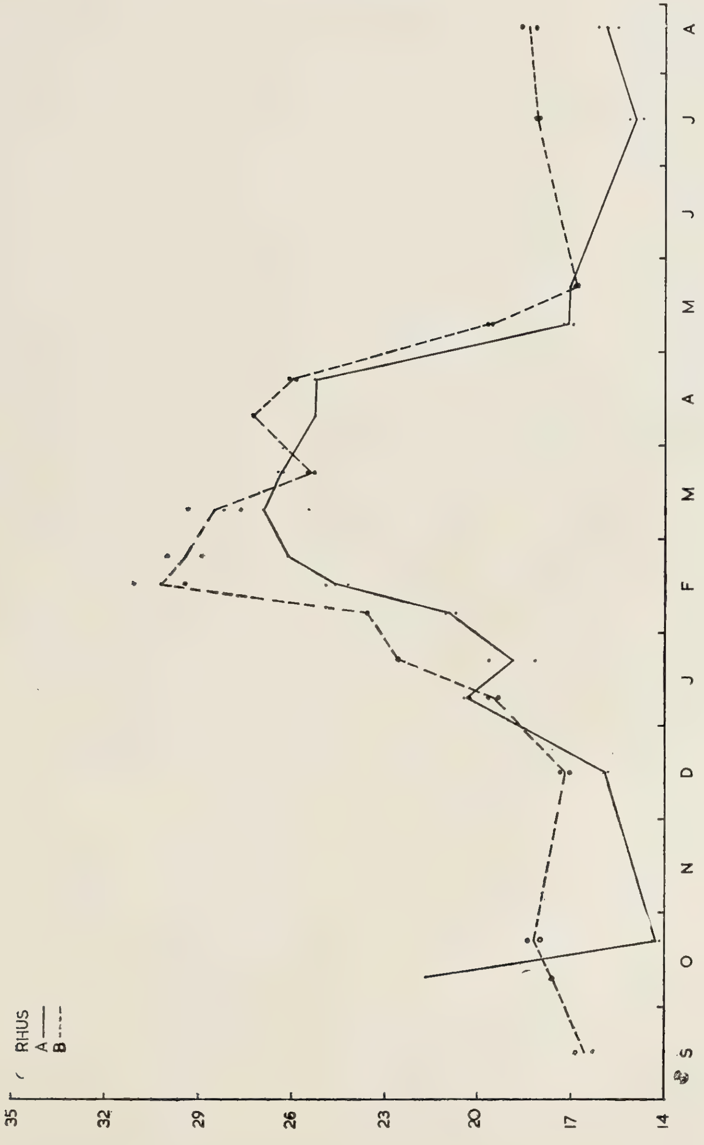

Fig. 4. Osmotic Pressures of *Rhus mucronata* Thunb.

conditions was, however, quite different. Both plants reached a maximum during February but *O. coronopifolia* reacted much faster to the small showers that fell during this month. It was only about a fortnight later that the osmotic pressure of *L. hypophyllum* also dropped sharply. This may be as a result of the deeper root system of the latter. The phenomenon repeats itself during the April—May period when a second maximum was reached, and even in the middle of August the osmotic pressure of *L. hypophyllum* was still considerably higher than during October of the previous year. The present graph corresponds well with that obtained by Walter and van Staden (1). It shows again that, in sandy soil, a plant with a strong root system utilizes the water which seeps down to a considerable depth and is little influenced by either small showers or sudden rises in temperature. Furthermore, the graph remains fairly flat, showing relatively small differences in the water condition of the plant during the different periods of the year.

Euclea racemosa (Fig. 3): On the whole the values obtained correspond well, with the exception of those obtained during October, 1967 and February, 1968, where there is apparently a very considerable experimental error. The amplitude is in this case much higher than in the former two, the osmotic pressure varying between almost 12 atmospheres to slightly over 26 atmospheres. The small showers from December, 1967 to February, 1968 had only a slight influence on the water relations of the plant. Only the continual showers from April, 1968 to August caused a sharp decline in the osmotic pressure.

Rhus mucronata (Fig. 4): Again the results correspond well, but there are a few cases where the variation is large. The graph shows the same general trend and a close correspondence with that of *E. racemosa*. The shrubs grow close together at the foot of a dune, but the leaves of the former are both smaller and more leathery than those of the latter. Yet the maximum osmotic pressure of the former is slightly below that of the latter. The maximum was reached in February, 1968. As in the former species, a decline appeared during March, the driest month of the period under observation.

Olea africana (Fig. 5): Leaves from specimens at two stands were collected and investigated, both in the vicinity of the former two species, viz. at the foot and at the top of the dune. The most striking characteristic of these two graphs is the exceptionally high osmotic pressure reached during March, 1968, when the other species showed a slight decline and a very sharp drop in osmotic pressure during the latter half of April to May, 1968. In both cases the difference between the osmotic pressure of the older and younger leaves is relatively slight during the periods of maximal value, the osmotic pressure of the older leaves being often slightly lower than that of the younger leaves. At this stage, as can be expected, active growth had stopped completely and the younger leaves were almost as hard and leathery as the older ones.

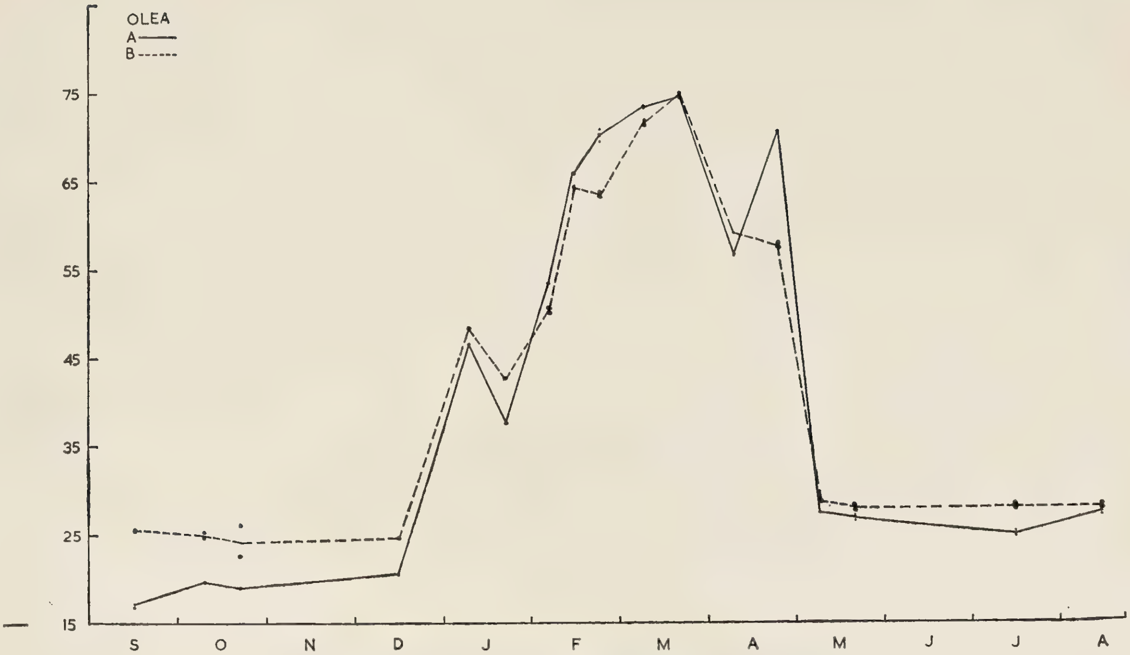

Fig. 5. Osmotic Pressures of *Olea africana* Mill. at foot of dune.

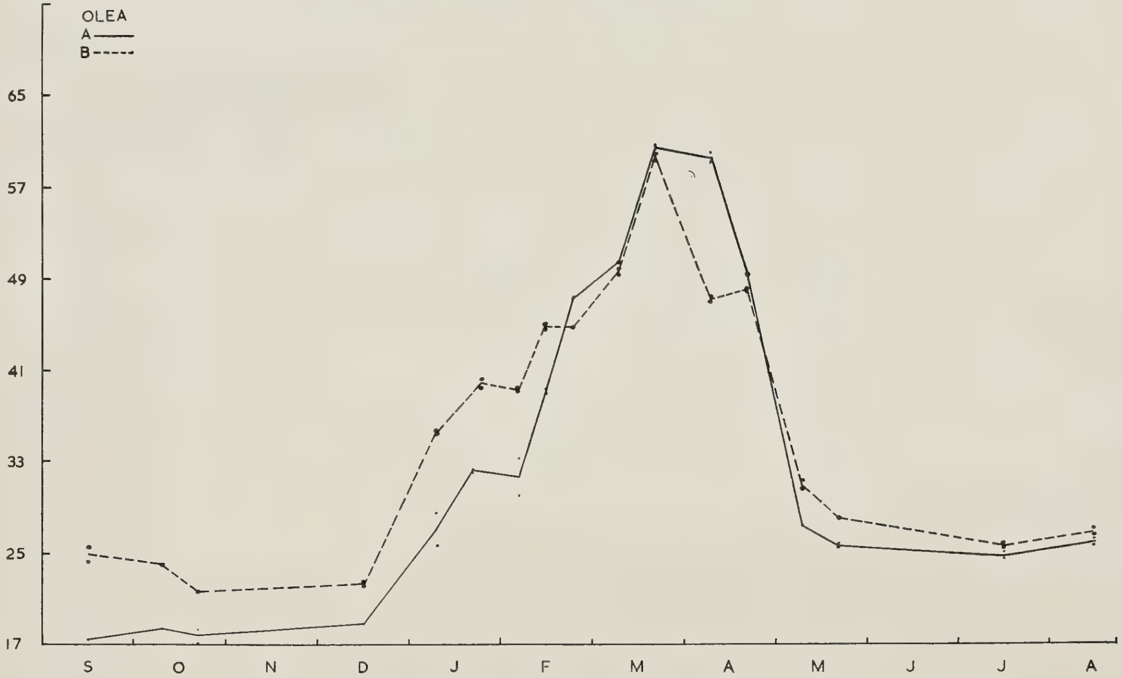

FIG. 6. Osmotic Pressures of *Olea africana* Mill. on top of dune.

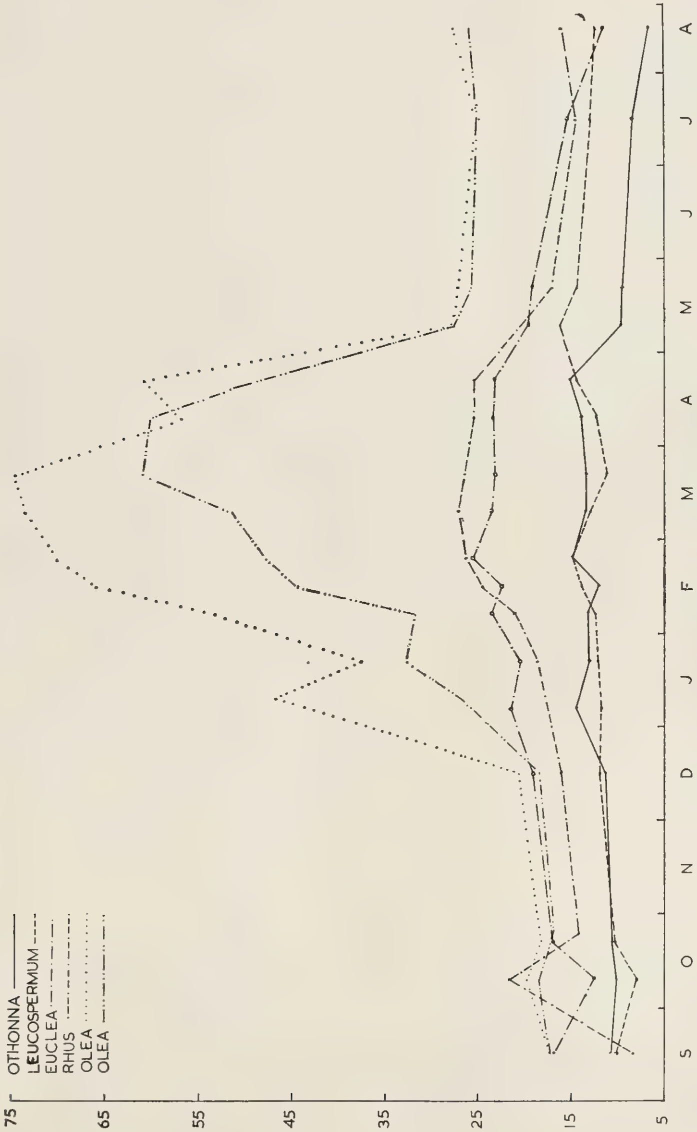

FIG. 7. Comparative graph of Osmotic Pressures.

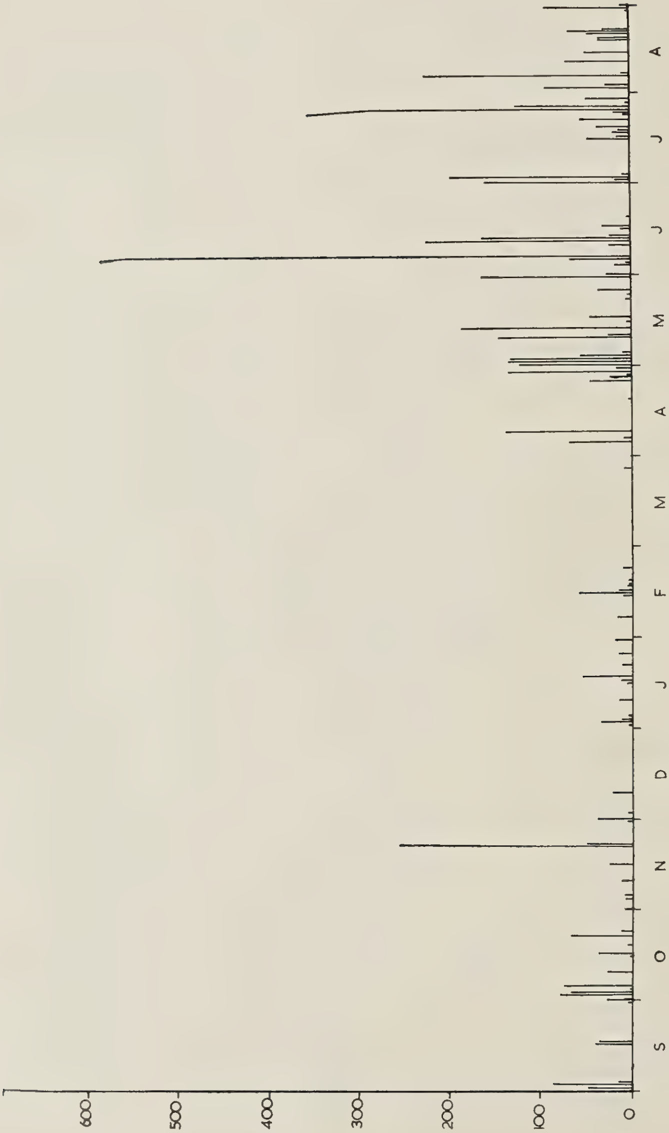

FIG. 8. Rainfall in mm during period of observation.

Most unexpected is the fact that the osmotic pressure of the plant at the foot of the dune was constantly higher than that of the specimen at the top of the dune in spite of its greater exposure to the elements. The latter plant was consistently in a better condition throughout the period of investigation. During October, 1967 this latter plant was in bloom and fruit-bearing during November of the same year. The former plant did not bloom during the period of investigation and the leaves became very hard and slightly curled up during February and March, 1968. The quantity of leaf material collected had in both cases to be increased to yield the required amount of cell-sap for cryoscopy. This unexpected result cannot be explained at present, but the problem is being investigated further.

It is an interesting fact that, with the exception of *O. africana*, there has in each case been a drop in the osmotic pressure during March, 1968, the driest month during the period of observation. This may be due to a considerable number of cool, overcast days with a very slight drizzle when no precipitation could be measured. This seems to show that the roots are in contact with subterranean stores of water which ensure their existence during these dry periods.

The comparative graph in Fig. 7 shows that *O. coronopifolia* and *L. hypophyllum* are hydro-stable, there being relatively little variation in the osmotic pressure. *O. africana*, on the other hand, is hydro-labile with a variation from approximately 16 to 74 atmospheres, while *E. racemosa* and *R. mucronata* occupy a position in between. Furthermore, the active vegetative and reproductive activities occur when the osmotic pressure is comparatively low, but the osmotic pressure of a zerophytic species, such as *O. africana*, never sinks as low as that of a semi-succulent such as *O. coronopifolia*. This again raises the question: which plants are zerophytes? *L. hypophyllum* has leathery leaves with a thick cuticle and well protected stomata, yet the osmotic pressure of its cell-sap is almost as low as that of *O. coronopifolia*. Anatomically it shows characteristics according to which it could be classified as a zerophyte, but the osmotic pressure of its cell-sap is more in accord with that of a mesophyte of Walter (5).

SUMMARY

1. Curves of the osmotic pressure of the cell-sap of five indigenous species, on the campus of the U.C.W.C., have been determined for a period of one year.
2. The curves generally show a crest during periods of drought (the summer months) and a trough during the rainy season (the winter months).
3. *Othonna coronopifolia* L. and *Leucospermum hypophyllum* R. Br. are hydro-stable plants, showing a small variation in the osmotic pressure of the cell-sap throughout the year.

4. *Olea africana* Mill. is hydro-labile with a wide variation in the osmotic pressure of its cell-sap.
5. *Euclea racemosa* Murr. and *Rhus mucronata* Thunb. are in between.
6. The specimen of *Olea africana* on top of the dune showed more favourable hydrological conditions than the specimen at the foot of the dune.

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